Nelson Forest Region	**Partial Cutting Options in Hemlock-Dominated Stands in Southeastern British Columbia: The Selkirk College Woodlot Experience**	
	Extension Note 041	

INTRODUCTION

In southeastern British Columbia (BC), many stands on north-facing slopes in the Interior Cedar-Hemlock moist warm (ICH mw2) biogeoclimatic zone are dominated by mature or overmature western hemlock. The hemlock trees in these stands are often of questionable timber quality due to a range of pathogens, most notably Indian paint fungus (*Echinodontium tinctorium*). Even when the hemlock component is mostly sound, concern over windthrow and other risk factors prompt forest managers to clearcut these stands.

- ***Both group selection and dispersed retention of overstory hemlock can be achieved for structural diversity with minimal windthrow losses on sites where dominant hemlock, or groups of hemlock, can be retained.***
- ***Dispersed retention of thin-barked hemlock can still be successful even on slopes up to 55%, where care is taken in layout and harvesting.***
- ***Clearly communicating the objectives of partial cutting to the crew is critical to harvesting success.***

Selkirk College acquired a Woodlot License (WL 400) in 1986, the first college in the province to do so. The College's Renewable Resources Program uses WL 400 as a demonstration forest to illustrate to students a variety of stand treatments, silvicultural systems, harvesting methods, and site preparation and reforestation techniques.

Initially, Selkirk College approached management of the hemlock-dominated stands with the traditional approach of clearcutting. In the 1990s, the College became interested in alternative approaches.

From 1994 to 1996 a range of partial-cutting silvicultural systems were implemented in the Blueberry Creek compartment on the woodlot, and the College's experiences with these are discussed here.

BACKGROUND INFORMATION, WOODLOT 400

The Selkirk College woodlot has an allowable annual cut of 1184 m^3 and it is managed on a five-year cut-control basis. It is divided into two areas: the Blueberry Creek compartment is 381 ha, and the Little McPhee Creek compartment is 220 ha.

The Blueberry Creek compartment is located in the Blueberry Creek Community Watershed, south of Highway 3, approximately 10-14 km west of Castlegar. This portion of the woodlot is in the Interior Cedar-Hemlock moist warm variant (ICH mw2). Soils are predominantly silty or sandy loam, and slopes range from 15 to 55% with pitches up to 70%. Aspect is primarily northeast and elevation ranges from 880 to 1400 m.

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Timber type is predominately Hw_{60}, Fd_{10}, Lw_{10}, Pw_{10}, Cw_5, Se_5. Merchantable volume is approximately 250-350 m^3/ha, and timber quality is generally average. Some portions of the woodlot were harvested under intermediate utilization standards in the 1940s and 1950s. A majority of the stands are fire-originated from major stand-replacing fires, the most recent being 1925.

MANAGEMENT OBJECTIVES

For the Blueberry Creek compartment of the College woodlot, management objectives include the following:

Watershed Management

1. Maintain water quality in the community watershed of Blueberry Creek and its tributaries.
2. Experiment with, and focus on, using partial-cutting silvicultural systems to minimize increases in Equivalent Clearcut Area (ECA). ECA is now close to its maximum in College Creek, a small tributary of Blueberry Creek (although the College woodlot has a relatively small impact on the total ECA in this drainage).

Biodiversity and Habitat Management

1. Develop and demonstrate approaches to harvesting that encourage a wide range of habitat structures for a diversity of species.

Timber Production

1. Maintain site quality and productivity by minimizing detrimental soil disturbance. Because the allowable annual cut (AAC) for the woodlot is small and encourages use of small cutting units, and because most harvesting is on moderate to steep slopes, there is potential to incur high amounts of disturbance per area harvested. The College endeavors to minimize these potential impacts on productivity by keeping disturbance levels within accepted guidelines.
2. Produce quality sawlogs with a diversity of conifers and hardwoods—up to 15% of the latter—on a 90-year rotation.

Visual Quality

1. Meet a Visual Quality Objective of Partial Retention for blocks visible from Highway 3.

Education

1. Provide demonstration areas for use within the Renewable Resources Program at Selkirk College. Demonstration areas should provide learning opportunities that include:
    i. Silvicultural systems and harvesting approaches.
    ii. Stand dynamics and structural manipulations in mixed species ICH stands.
2. Experiment with a range of partial-cutting options in hemlock-dominated stands and compare results with clearcutting for the purposes of:
    i. Addressing management objectives, especially for wildlife habitat and watershed issues.
    ii. Addressing forest health concerns.
    iii. Maintaining timber growth, yield, and quality within an acceptable range

MANAGING UNDERSTORY HEMLOCK WHILE MAINTAINING VERTICAL STRUCTURE (BLOCKS 2 AND 3)

Site-Specific Challenges and Issues

In addition to the general management objectives for the woodlot, the following issues and challenges on Blocks 2 and 3 (Table 1) were critical to successful management.

- The high-quality, prolific, natural understory prompted a desire to also retain as much of the advanced regeneration as possible. Subsequent growth and development of the young stand will be compared with neighbouring clearcut plantations.
- Because most natural regeneration was hemlock, the College wanted to regenerate a component of seral intolerant species like larch, Douglas-fir, white pine, or lodgepole pine. This would require some openings with sufficient light penetration into the stand.
- Presence of Armillaria was evident on Block 2A. Other blocks showed few signs of Armillaria, although the pathogen is assumed to be present throughout the woodlot.
- Layout and harvesting would require more careful attention than usual to avoid excessive damage to the regeneration and the overstory retention on the moderately to steeply sloped terrain and the sensitive soils found on Block 2B (see site description in Table 1).
- Visual quality for Block 2 was also a concern from viewpoints along Highway 3.
- Past harvesting created distinct canopy gaps in Block 3 which developed into the existing numerous patches of understory hemlock-dominated regeneration. Past harvesting in Block 2A was very light, so the subsequent understory regeneration patches are small and widely dispersed. Past harvesting and steep drier conditions in Block 2B contributed to a very open overstory with a continuous heavy understory dominated by hemlock.

Table 1. Site descriptions, Blocks 2 and 3.

Size of cutting unit	*Block 2A* = 2.02 ha. *Block2B* = 2.38 ha. *Block 3* = 2.4 ha.
Soil	*Block 2A* = Sandy loam with compacted sand and gravel restricting layer at 55 cm. *Block 2B* = Colluvial sandy loam with 30-70% coarse fragments. *Block 3* = Silty loam with compacted sand and gravel restricting layer at 55 cm.
Slope	*Blocks 2A and 3* = 15-35% *Block 2B* = 30 - 60% with occasional pitches to 70%
Stand considerations	Blocks were selectively harvested on the 1940s and 1950s to remove red-cedar poles and large diameter Douglas-fir sawlogs. • Past harvesting in *Block 2A* was very light, so subsequent understory regeneration patches are small and widely dispersed. • In *Block 2B*, past harvesting and steep drier conditions contributed to very open overstory with continuous heavy understory dominated by hemlock • In *Block 3*, past harvesting created distinct canopy gaps which developed into existing numerous patches of understory dominated by hemlock regeneration.

Silvicultural System

A *natural shelterwood with overstory retention* was used to release the natural understory, while maintaining structural diversity in the overstory.

A range of species were left in the overstory including hemlock, larch, white pine, redcedar, spruce, and Douglas-fir. In Block 2A, larch, birch, and aspen were favoured over Douglas-fir due to Armillaria concerns. Large dominant or co-dominant trees were chosen for retention, with diameters ranging from 35 to 70 cm and heights from 25 to 45 m. Approximately 5-10 m^2/ha of overstory were retained in a clumpy fashion, except in Block 2B where only 2-5 m^2/ha were left above a more consistent understory.

Harvesting

All overstory retention was marked-to-leave prior to harvesting. The woodlot manager worked closely with the fallers and the contractor to ensure both the overstory retention and understory regeneration would be protected.

All blocks were groundskidded; Blocks 2A and B with a John Deere 650TC crawler-tractor, and Block 3 with a rubber-tired skidder. A three-person crew was used on Block 2 while a four-person crew was used on Block 3. On both units in Block 2, harvesting operations were conducted in the winter on a compressible, 1-m snowpack to minimize disturbance on the sensitive slopes. Block 3 operations were completed in the summer. To negotiate the steeper terrain in Block 2B the crew used one steep climbing trail with a series of contour branches.

Lessons for Management

1. Silvicultural System Lessons

a) By utilizing the advanced regeneration, particularly where it was consistent as in Block 2B, several advantages were realized:

- It is anticipated that the rotation length may be shortened if the regeneration responds with expected growth rates. This response will be monitored over time.
- Regeneration costs were lowered because fewer seedlings were planted.
- The advanced regeneration, combined with planted stock, provides even greater structural and species diversity which in turn provides more options for future management.

b) Several disadvantages associated with management of the advanced regeneration were also recognized:

- The retained understory clumps now require a "quality spacing" to reduce extreme densities, and remove damaged and poor quality overtopping stems. In addition to harvesting damage, some snowpress damage in smaller stems has occurred since harvest—most notably during the winter of 1996-97.
- Estimating planting requirements was difficult in advance of harvesting because planting could be accomplished only in scattered openings, most of which were created through harvesting activities. A walkthrough after harvesting was required before planting stock could be ordered.

c) On Block 3, several large larch veterans, greater than 40 m high, were retained to provide structural diversity for cavity nesting birds and perching raptors. In retrospect, this objective had the advantage of possibly reducing understory damage because felling the large timber would have inflicted considerable damage to the regeneration. Also, in spite of their significant volume, it was also suspected that "ring shake" and "pocket-rot" defects compromised timber quality of the larch.

2. Harvesting Lessons

a) The woodlot manager felt that the key factor for success was close communication with the loggers, particularly the faller. The manager worked with the faller every day during harvesting operations. Objectives were clarified and constantly reinforced, and the faller and the manager together could work out the best strategies to fit with different falling and skidding situations within the blocks.

b) To avoid excessive damage to the understory, trails were prelocated to access natural openings. The faller then directionally felled the timber past understory clumps and overstory retention into the openings. Hot logging (i.e. where falling and skidding occur concurrently) was used to reduce the cumulative volume in the openings; however, often this tactic delayed falling, thereby resulting in lower harvesting productivity in Block 2.

c) On steeper slopes (30-50%) the compressible snowpack was critical for keeping bladed trail disturbance to a very minor amount.

d) Although groundskidding was successful in Block 2B, even with a steep climbing trail that sometimes exceeded 40%, such an approach would not be acceptable today under new Workers' Compensation Board (WCB) regulations. Future entries will be yarded with a small skyline cable yarder. An upper road location is being sought to best facilitate this approach.

e) Marking was easily accomplished using a running tally of trees marked to meet a pre-calculated total for the block based on the target basal area. While this approach may be cumbersome on larger blocks, it is easily applied on small units.

GROUP SELECTION AS A PARTIAL CUTTING OPTION (BLOCK 4)

Site-Specific Challenges and Issues

Few issues existed on Block 4 (Table 2) that led directly to the choice of a group selection system. Rather, the system was chosen mostly to demonstrate an option that may have advantages for:

- Prolonging snowmelt, thereby reducing peak flows for watershed management. One of the small openings was originally planned as a research trial in conjunction with the Research Section of the Nelson Forest Region; however; timing of harvesting pre-empted the establishment of the trial.
- Reducing windthrow in hemlock-dominated stands.

Table 2. Site description, Block 4.

Size of cutting unit	7.0 ha block with three openings ranging from 0.5 to 0.9 ha.
Soil	Silty loam with compacted coarse sand and gravel restricting layer at 55 cm.
Slope	15-35%.
Stand considerations	Previously harvested to remove white pine infected with blister rust.

Silvicultural System

A first entry *group selection* was used with two 0.5-ha openings and one 0.9-ha opening in the first pass. Although the current openings are slightly larger than the guidebook definition of group selection, the future openings will be smaller. Four to five passes are planned with a cutting cycle of 15 to 20 years between passes.

Harvesting

Trails were prelocated and the openings were oriented east-to-west to maximize their snow-holding capacity. Harvesting was undertaken in September 1994, using a four-person crew consisting of a bucker/loader operator, a skidder operator for the rubber-tired line skidder, a processor operator, and a faller.

Lessons for Management

1. Silvicultural System Lessons

a) The openings roughly demonstrate the value of group selection for prolonging snowmelt in the spring. During late April to early May generally half of the openings will be snow-free, while the other half will have 30-40 cm of snow.

b) While opening orientation prolonged snowmelt, it also created a significant shade-wall on the south side of each opening, which became a challenge for regeneration of mixed species. Planted lodgepole pine is currently growing well on the north side of the openings where direct sunlight is prolonged for much of the day. In the southern shaded zone, lodgepole pine is the poorest performer of all species. In this zone, prolific natural hemlock will overtake all planted intolerants. Future group selection openings will likely be oriented north-to-south to minimize the shade-wall influences.

c) No windthrow has been experienced in these openings, which averaged between two and three tree lengths in width. In the future, systems with small group or strip openings will be used in areas with higher windthrow concerns, such as the west end of the woodlot, which is surrounded by riparian reserves. Widths of new openings will be adjusted downward with higher windthrow hazards.

2. Harvesting Lessons

a) The gentle and relatively uniform terrain of this block was suitable for a group selection system with groundskidding. Such an approach requires a total chance initial trail layout between openings. The trails must be designated as permanent and will be used again to access future openings in subsequent passes. Likely a larger block with more openings per entry than could be used on the woodlot would provide a greater economy of scale.

b) Harvesting was slowed by the small size of openings. In some cases the faller had to drop a few trees at a time and then wait for them to be skidded, until enough of a cutting face was developed to allow for safe separation of operations.

c) On this block, butt skidding appeared to have some advantages for skidding around tight turns.

d) Soil disturbance objectives could be met by keeping skid trails at an absolute minimum width.

USING A MIX OF GROUP AND DISPERSED RETENTION TO INCREASE STRUCTURAL DIVERSITY IN A HEMLOCK STAND (BLOCK 5)

Site-Specific Challenges and Issues

Table 3. Site description, Block 5.

- Block 5 is not visible from Highway 3, so meeting Visual Quality Objectives was not a concern here.
- The pre-harvest stand contained a significant component of hemlock (Table 3) therefore windfirmness was a concern for potential hemlock leave-trees. However, dispersed hemlock leave trees were desired for several reasons. There were scattered patches of high-quality, advanced regeneration that were to be saved, and the large dominant hemlock with 20-m wide crowns could easily create considerable damage if felled in these patches. Also, as an experiment, the College wanted to see if dispersed hemlock leave-trees could remain windfirm on a site with a moderate windthrow hazard.
- There were some concerns that using ground skidding equipment on this steep site would damage the thin-barked hemlock, and cause soil disturbance.

Size of cutting unit	2.7 ha.
Soil	Silty loam with compacted coarse sand and gravel restricting layer at 55 cm.
Slope	20-55%.
Stand considerations	Very high percentage of hemlock. Most suitable leave trees were hemlock dominants due to lack of consistent distribution of suitable stems of other species.

Silvicultural System

The silvicultural system used in Block 5 is currently recognized in the Forest Practices Code regulations as *clearcut with group and uniform reserves*. However, some view this terminology as contradictory, and outside of BC such a system may be referred to as *group and dispersed retention.* The purpose of this system is to retain sufficient overstory structure from the previous stand to provide for a range of wildlife habitats. The retention included 2-5 m^2/ha of dispersed dominant hemlock with large, 20-m-wide crowns, and one island of trees with a variety of heights.

Harvesting

Reserve trees were marked-to-leave. Harvesting was conducted in September 1995. One designated climbing trail angled up to the corner of the block. Skidding was completed on the rest of the unit without bladed trails because of the dry soil conditions. The three-person crew consisted of a bucker/loader operator, a skidder operator for the crawler-tractor, and a faller (Figure 1).

Lessons for Management

1. Silvicultural System Lessons

a) Although three leave-trees blew over during harvesting operations, subsequent blowdown consisted of only one tree, which has not been salvaged. The tendency was for only the smaller hemlock codominants with a high height-to-diameter ratio (or low taper) to blow down. The results are encouraging for leaving hemlock dominants as dispersed leave trees on sites with a moderate windthrow hazard.

Figure 1. In Block 5, the crawler-tractor worked around reserve trees that had been marked prior to harvesting.

b) Although Block 5 has no objectives for visual quality, from the lower spur road it demonstrates the visual effectiveness of leaving a mix of group and dispersed retention (Figure 2). With only one sizable group of retention left, the visual effect is significantly more natural than if all leave-trees were dispersed uniformly.

2. Harvesting Lessons

a) Harvesting damage was very low—virtually non-existent. Good initial communications between the woodlot manager and the harvesting crew helped clarify the intent for the leave trees. The crew felled a number of standing snags higher than normal to serve as rub stumps. The woodlot manager noted that the crew was experienced with partial cutting and they liked the challenge it presented. This attitude was reflected in their general care for the residual stand.

b) The qualified and conscientious crew also helped ensure that soil disturbance was kept to an acceptable level. They used one main climbing trail, and conducted skidding operations in a careful manner. Although the site is steep, current WCB standards would likely still allow for this type of groundskidding as long as small crawler-tractors were used.

Figure 2. A combination of group retention and dispersed retention was used on Block 5 to increase structural diversity of the hemlock stand.

REFORESTATION ON ALL BLOCKS

On all blocks, advanced regeneration was protected wherever possible. Although prolific hemlock natural regeneration was expected, a mixed species stand was desired. Therefore, all blocks, except Block 2B, were planted with a variety of species such as white pine, Douglas-fir, larch, and lodgepole pine. Planting density varied between 800 and 1400 stems/ha depending on the density of the residual advanced regeneration.

Planted seedlings encountered no problems with establishment and growth, with the exception of white pine and larch.

In 1997 the larch struggled with needle cast and incurred about 30% mortality; in 1998 the larch seemed to be doing well. Also, deer and elk browsed the terminal bud on almost every newly planted white pine near the edges of openings. In contrast, no naturally regenerated white pine were browsed. In fact, in 1997 the planting rows could be discerned by looking for the browsed pine.

The browsing was not anticipated because the woodlot was believed to be far less important for winter ungulate habitat than nearby areas on the north side of Blueberry Creek. The attraction to planted white pine may be short-lived. In 1998 the trees already appeared to be recovering from the initial browsing,

and were re-establishing apical dominance in a lateral branch.

Any required planting was carried out by Selkirk College Forestry students as part of their required practical training and education as technicians.

SUMMARY

Several options exist for managing hemlock-dominated ICHmw2 stands.

Where a prolific and consistent understory of acceptable advance regeneration exists, silvicultural advantages and limitations should be carefully weighed for each site. Often thoughtful layout and harvesting can minimize damage to the understory. Layout of trails to anticipated volume accumulations helps to minimize skidding damage, while close and consistent communication with the faller is usually the key in achieving harvesting success. Maintaining some overstory structure with larger veteran trees may have the benefit of further reducing damage to the understory while promoting a diversity of habitats.

Group selection may have some advantages for reducing windthrow when the opening width is properly matched to the windthrow hazard to reduce penetration of the wind profile into the stand. Although small group openings may hold some advantages for prolonging snowmelt and reducing peak water flows in community watersheds, subsequent shadewalls may have detrimental impacts on establishment of seral intolerant trees.

Windthrow, snowmelt, and regeneration impacts must all be considered before a decision on orientation is made. A total chance approach to trail layout is required when groundskidding with group selection, and main trails should be considered permanent access. Large units with many openings per pass may provide a better economy of scale for harvesting; however, planning and layout may become more complex and costly.

Both group and dispersed retention of overstory hemlock can be achieved for structural diversity with minimal windthrow losses on sites with moderate windthrow hazard when dominant hemlock, or groups of hemlock, can be retained. A mix of group and dispersed trees may have a visual advantage of appearing more natural. Dispersed retention of thin-barked hemlock can still be successful, even on slopes up to 55%, where care is taken in layout and harvesting.

For any partial cutting, close communication of the objectives with fallers provides an understanding that is critical to harvesting success. Also, the faller can then collaborate with the forest manager to develop falling strategies that work with the silvicultural objectives and the skidding limitations.

Selkirk College will continue to monitor these blocks and compare them to adjacent clearcuts to increase general understanding of growth and yield, forest health, and wildlife habitat use in partially cut stands.

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